MASSACHUSETTS

INSTITUTE OF TECHNOLOGY,

BOSTON.

COURSES

IN

ELECTRICAL ENGINEERING AND PHYSICS.

BOSTON:
PRESS OF ALFRED MUDGE & SON,
No. 24 Franklin Street.
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MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

PRESIDENT	. . . . .	FRANCIS A. WALKER, LL. D.
SECRETARY	. . . . .	H. W. TYLER, PH. D.

COURSES OF INSTRUCTION.

The Institute offers thirteen distinct courses, each four years in duration, and leading to the degree of Bachelor of Science, as follows : —

I. CIVIL ENGINEERING (including options in Railroad and Highway Engineering and in Geodesy).

II. MECHANICAL ENGINEERING (including options in Locomotive, Mill, and Marine Engineering).

III. MINING ENGINEERING AND METALLURGY.

IV. ARCHITECTURE.

V. CHEMISTRY.

VI. ELECTRICAL ENGINEERING.

VII. BIOLOGY.

VIII. PHYSICS.

IX. GENERAL STUDIES.

X. CHEMICAL ENGINEERING.

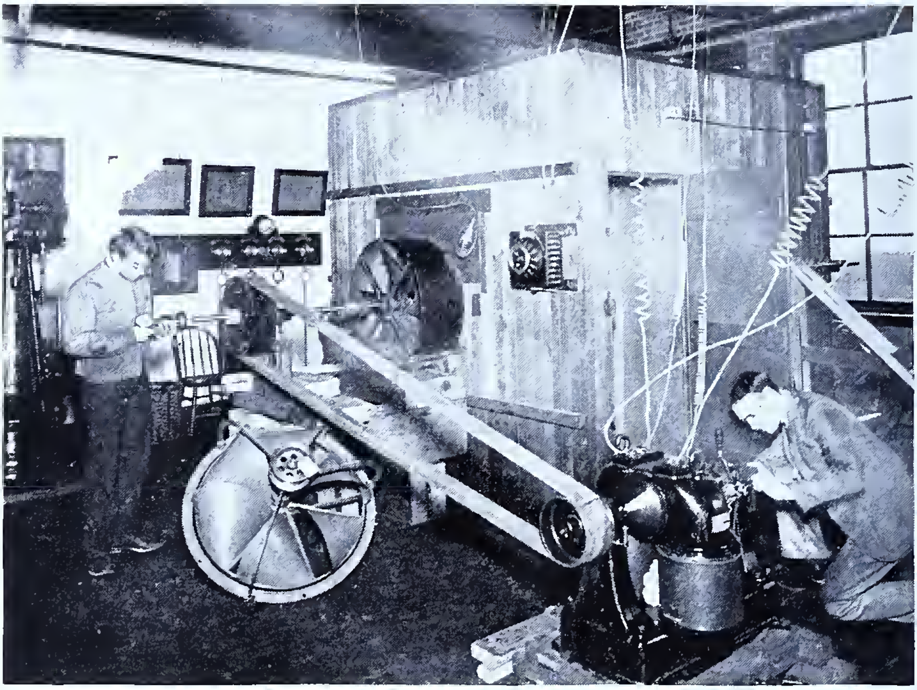
XI. SANITARY ENGINEERING.

XII. GEOLOGY.

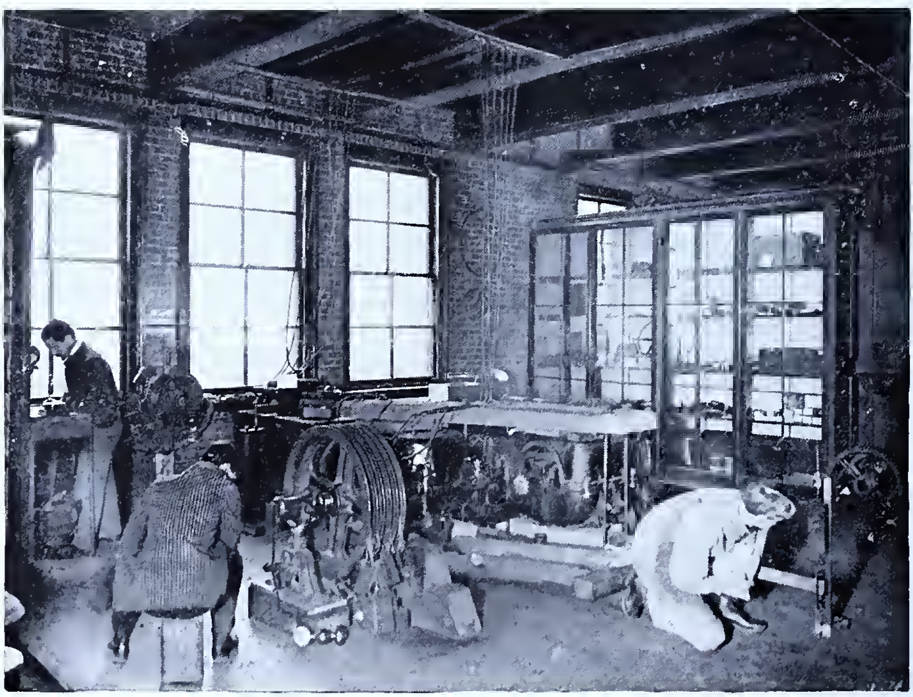
XIII. NAVAL ARCHITECTURE.

TABLE OF CONTENTS.

The present pamphlet, while complete in itself, is especially designed to supplement and extend the statements regarding the courses in Electrical Engineering and Physics which are given in the annual catalogue of the Institute. The catalogue should also be read by one purposing to enter upon either of the courses mentioned. It may be obtained by addressing the Secretary of the Faculty, Prof. H. W. Tyler.



THESIS WORK: TESTS OF ELECTRICALLY-DRIVEN FANS.



THESIS WORK: TESTS OF ELECTRIC RAILWAY MOTORS.

THE COURSE IN ELECTRICAL ENGINEERING.

COURSE VI.

Origin of the Course.

Early in the history of the Institute the subject of electrical measurements was recognized as of great importance, and the ordinary methods of testing, then in vogue, were taught. This instruction was gradually enlarged in scope. With the increased extent of the applications of electricity, consequent upon the invention of the speaking telephone in 1876, and the practical introduction of electric lighting a few years later, the lectures and laboratory practice in electricity were very considerably extended, and special courses of lectures were also introduced relating to the technical uses of electricity in telegraphy, telephony, and electric lighting. These lectures, although delivered outside of the regular hours of the school day and without any requirement of attendance upon them, were, nevertheless, so fully appreciated that it was felt that the Institute might well offer to its students the opportunity of pursuing a systematic course which should fit them to enter upon the new profession of Electrical Engineering. That this need was one felt in other places was made clear by the attention which had been called to it abroad by various writers, and especially by Professor Wm. E. Ayrton, of London, whose important endeavors in the same line, in connection with the City and Guilds of London Institute, served at once as a stimulus and a guide. At this time there was no opportunity for any thorough and consecutive study in electrical engineering to be found in this country, and but very little elsewhere. It was therefore resolved by the Corporation of the Institute to establish such a course, and the institution of this was formally announced in the summer of 1882. In September of the same year the work of the course was begun.

Applicants were received at first only in the lowest year of the course, but, notwithstanding this restriction, six regular students were

enrolled as belonging to it upon its beginning. The first men to complete the course graduated in 1885. The following list gives the number of regular students, *i. e.*, candidates for a degree, pursuing the full course, and of special students, taking only a partial course, in each successive year up to the present time, and also the number of graduates in each year. The data regarding the undergraduate students are based on the attendance lists for the beginning of the school year. It should be remarked that from the opening of the course no special students have been received except those whose qualifications in mathematics, chemistry, and physics have been such as would have allowed them to become candidates for a degree so far as these particular studies are concerned.

NUMBER OF STUDENTS PURSUING COURSE IN ELECTRICAL ENGINEERING.

	Regular.	Special.	Graduates.
1882–83	6	1	–
1883–84	18	9	–
1884–85	30	17	2
1885–86	41	14	10
1886–87	52	10	8
1887–88	61	6	17
1888–89	74	7	17
1889–90	91	6	18
1890–91	105	26	23
1891–92	108	16	36
1892–93	112	33	41
Total number of graduates in Course VI.			172

Characteristics of the Course.

The course in Electrical Engineering is intended to meet the needs of young men desirous of entering upon the practice of any of the various applications of electricity in the arts, as, for example, telegraph and telephone engineering, electric lighting, the electrical generation, distribution, and utilization of power.

A consideration of the scheme of studies, given upon a later page, will show clearly the fundamental principles which have been kept in mind in shaping this course, which may be summarized as follows : —

(1.) In most large work in electrical engineering, the questions

involved are not merely electrical in their nature, and oftentimes they are not chiefly so. The decision as to whether the erection of a plant under given circumstances is financially advisable, or as to which is the best of several possible modes jo procedure, is generally an economic one, and involves a knowledge of structures and machinery quite as much as of electrical details; and in most branches of Electrical Engineering, the design and handling of machines, of one or another kind, is a constant necessity. For this reason the course aims to train electrical engineers, — not mere electricians. Its original plan fully recognized the principle, afterwards so forcibly stated by Lord Kelvin, that electrical engineers "must before all be engineers; they must be engineers, and they must learn electricity."

To carry out this important end, the student in electrical engineering spends a very large portion of his time in the laboratories and lecture rooms of the departments of Mechanical Engineering and Applied Mechanics. As will be seen from the scheme of studies, shopwork, the principles of mechanism, mechanics, and the strength of materials, thermo-dynamics, and steam engineering, are all recognized as forming an essential part of his professional work.

(2.) On the other hand, it will be observed that this course is not simply a course in Mechanical Engineering with elective studies in electricity, or with only a single year devoted to this subject. Almost from the time the student chooses his course, his work is differentiated from that of the student in mechanical engineering. In the second year he receives special instruction in acoustics and electricity in the lecture-room, and also begins work in the physical laboratory. In the third year, the courses in theoretical electricity, the methods of telegraphy, the construction and use of electrical measuring instruments, and the work pursued in the physical laboratory, are all peculiar to the course in Electrical Engineering. And in the last year of the course by far the greater portion of the student's time is spent upon technical electrical studies.

(3.) In laying out Course VI., it has been felt that no electrical engineer can be considered as properly educated without a good knowledge of mathematics and its applications to electrical subjects. Especially is this important in the development of alternating current machinery and the investigation of the unrevealed possibilities

of electric oscillations. And it is probable that in the future there will be a much greater call than in the past for the use of more advanced analytical methods in connection with problems of electrical engineering. On the other hand, it is recognized that one may be a competent engineer without any very exceptional mathematical ability; and hence it has been thought wise to terminate the required work in pure mathematics with the subject of differential equations, while allowing students who are competent and desirous of further mathematical instruction to pursue quaternions, the Fourier mathematics, spherical harmonics, analytical mechanics, and mathematical electricity, to as great an extent as they desire.

(4.) In common with all the courses at the Institute, this is intended to give to the student a broad and generous training which shall fit him to consider intelligently any of the various questions which may be presented to him as a scientific man or as a citizen. Its design is first of all to teach him to be accurate in his observations and logical in his deductions from them, and to train him in such habits of thought that he may be able at any time to concentrate the whole of his knowledge upon the subject immediately in hand. A high value is set upon the instruction in English literature and composition, business law, history, and political economy. French and German, though studied especially for their professional value, serve in addition to this to give valuable linguistic training. Furthermore, in the teaching of the more purely professional subjects, the endeavor is always made to discipline the hand and eye and mind rather than merely to teach special processes or to impart particular facts. To arouse in the pupil a love of study and a desire for investigation, so that he shall be unwilling to accept any partial explanation or any knowledge based solely upon empirical methods, is recognized as of fundamental importance. It is felt that no handicraft, however subtile, and no memorized information, however accurate, can compensate for the lack of sound judgment and the inability to solve new problems as they arise.

Character and Sequence of Studies.

As will be seen from the scheme of subjects in this course, its leading studies are physics, especially theoretical and applied electricity, mechanical engineering, and mathematics. To these

are added, for the sake of general information and manly culture, studies in history, literature, political economy, and French and German; the latter being also of direct value in obtaining at first hand a prompt acquaintance with the results of invention and discovery. Of the technical studies of the course, those in engineering run parallel with the electrical subjects, since in all branches of electrical engineering a sound knowledge of mechanics and motors, of measurements of power and the means of its transmission, etc., is essential. Thus, through the second year, the students pursue the studies of mechanism, shopwork, and drawing, and in the third year, the subjects of applied mechanics, steam engineering and hydraulics. Certain of these subjects are also continued into the fourth year.

In the Department of Physics, students in electrical engineering follow an extended course of lectures on general physics, and in addition to this, make a particular study of acoustics with especial reference to its applications in telephony.

In the second term of the second year special lectures, readings, and recitations on electricity are begun by which the study of the theory of electricity is continued until the middle of the fourth year, or if the student desires, until the end of that year. Work in the physical laboratory begins at the middle of the second year and continues throughout the third and fourth years.

In these years also there are extended courses of lectures devoted to the detailed consideration of the various technical applications of electricity to land and submarine telegraphy, the telephone, electric lighting, and the electrical generation and transmission of power. Instruction is given by lectures and laboratory exercises upon the processes of photometry, especially as applied to the measurement of electric lights. Advanced instruction in electrical measurements, including work with dynamo-electric machinery, together with a course on the electrical testing of telegraph and telephone lines, is provided. The subjects of construction, specifications, and contracts also receive attention.

During the second term of the fourth year every student is required to prepare and present a thesis involving original work in some branch of experimental or technical electricity.

In addition to the various required and optional studies mentioned

in the schedule of topics, students having the requisite preparation and ability may pursue more advanced courses in the mathematical theory of electricity and allied subjects.

Throughout his course the student is given the largest liberty of extending his studies as far as he wishes and as his time will permit; but he is not allowed to proceed to the later and more exacting work until that which precedes it has been completed to the satisfaction of his instructors.

Detailed Description of the Course of Study.

First Year. — The first year is to be regarded as a preparatory one. The student chooses his course at the middle of the year, and during the second term completes his work in the elementary mathematics, chemistry, and the principles of mechanical and free-hand drawing.

Mathematics. — The mathematical requirements in Course VI., in addition to the elementary branches, include analytic geometry, the differential and integral calculus, and differential equations; also the subject of least squares, and the applications of this to the discussion of the precision of measurements. Other branches of mathematics, as quaternions, advanced calculus, and the Fourier, Bessel and other functions may be pursued by competent students.

PHYSICS AND ELECTRICITY.

General Physics. — The instruction in the principles of physics begins with a series of lectures common to all courses, in which the subject of physics as a whole is discussed. The various branches are treated both mathematically and experimentally, and attention is given alike to the theory and the practical applications of the different portions of the subject. The student begins this course on entering the second year and continues it until the middle of the first term of the third year. The topics treated are mechanics of solids, liquids, and gases, molecular mechanics, wave motion, optics, electricity, and heat.

Acoustics is given at length in a separate course; special attention being paid to those portions which are of importance in relation to the telephone.

SCHEDULE OF STUDIES

IN THE COURSE IN ELECTRICAL ENGINEERING.

FIRST YEAR.

First Term. (*Common to all Courses.*)	Second Term.
Solid Geometry. Algebra. General Chemistry. Chemical Laboratory. Rhetoric and English Composition. French (or German). Mechanical Drawing. Freehand Drawing. Military Drill.	Plane and Spherical Trigonometry. General Chemistry; Qualitative Analysis. Chemical Laboratory. Political History since 1815. French (or German). Mechanical Drawing and Descriptive Geometry. Freehand Drawing. Military Drill.

SECOND YEAR.

First Term.	Second Term.
Physics: Mechanics, Wave Motion, Optics (Lectures). Acoustics. Analytic Geometry. Descriptive Geometry. Principles of Mechanism. Carpentry and Metal Turning. English Literature. American History. German (or French).	Physics: Optics, Electricity (Lectures). Acoustics, Magnetism, and Electricity. Physical Laboratory: General Physical Measurements. Differential Calculus. Mechanism: Gear-Teeth; Machine Tools. Drawing. Carpentry and Wood Turning. English Literature and Composition. German (or French).

THIRD YEAR.

First Term.	Second Term.
Physics: Heat (Lectures). Physical Laboratory: General Physical Measurements. Theoretical Electricity. Methods of Telegraphy. Integral Calculus. General Statics. Steam Engineering: Valve Gears, Thermodynamics. Drawing. Political Economy. Business Law. German (or French).	Physical Laboratory: Heat and Electrical Measurements. Theoretical Electricity. Electrical Measuring Instruments. Strength of Materials: Kinematics and Dynamics. Steam Engineering: Boilers. Engineering Laboratory. Drawing. Political Economy and Industrial History. Business Law. German (or French).

FOURTH YEAR.

First Term.	Second Term.
Technical Applications of Electricity to telephony, electric lighting, electrical generation and transmission of power, etc. Physical Laboratory: General electrical testing; testing of telegraph lines, dynamo machines, etc. Theory of Alternating Currents. Photometry. Method of Least Squares. Steam Engineering. Dynamics of Machines. Engineering Laboratory. Strength of Materials; Friction. Hydraulics.	Technical Applications of Electricity. Differential Equations. Engineering Laboratory. Discussion of the Precision of Measurements. Thesis. *Options.* Quaternions. Physical Laboratory. Mathematical Theory of Electricity.

Physical Laboratory. — At the middle of the second year the class enter upon a general course of experimental work in the Rogers Laboratory of Physics. The work done in the laboratory is almost exclusively quantitative in character. It is designed particularly to acquaint the student with physical measuring apparatus and with the general nature of careful quantitative work. It is intended to increase his skill in manipulation; to add to his knowledge of physical laws and of the methods of determining physical constants; and to train him in proper methods of recording, computing, and discussing results. The earlier and simpler work serves chiefly to give practice in the use of methods or instruments which are employed as accessories later. This is succeeded by experiments in the mechanics of solids, liquids, and gases, and in optics. Heat and electrical measurements occupy the remaining and more difficult part of the course. A series of lectures, upon the construction and use of physical measuring instruments, is given in connection with these.

Accurate work is required throughout; and in connection with the use of instruments of precision, especially in the more advanced measurements, the student's attention is particularly directed to the study of possible sources of error and to the discussion of the effects of these on the results obtained, a short lecture course also being devoted to this subject.

Theoretical Electricity. — A special series of lectures on the phenomena and general principles of electricity, designed particularly for Course VI., runs parallel with the latter portions of the course upon general physics already referred to, so that at the close of the second year the student possesses a good knowledge of the fundamental laws of electricity. During the third year he acquires some idea of the applications of mathematics to the study of electrostatics and electro-kinetics, and in the fourth year is given a course particularly devoted to alternating currents.

Technical Electricity. — The instruction in the technical applications of electricity begins with a course of lectures on the principles and methods of telegraphy in the third year. In the fourth year are given extended courses of lectures upon submarine telegraphy, the telephone, electric lighting, and the electrical generation, transmission, and utilization of power. The arrangement of central

PHYSICAL LECTURE ROOM.

LABORATORY OF GENERAL PHYSICS.

stations and the peculiarities of different types of dynamos are likewise considered. Also a course of lectures is devoted to railway signalling, and another to the distribution of electricity for commercial purposes.

Electrical Measurements. — The elementary course in electrical measurements, already referred to, is followed by a more extended course of advanced experiments in the laboratory of electrical measurements. A careful study is made of the construction, peculiarities and uses of the different standard and secondary instruments for the measurement of current, electro-motive force and resistance, and of the various processes employed in determinations of these under different conditions as to the magnitude of the quantities to be measured. To this succeeds work of a still more distinctively technical character. Thus, among other things, the student measures the specific resistance and conductivity of wires, the insulation resistance of cables, the electrostatic capacity of condensers, and the illuminating power of electric lamps, both arc and incandescent, and makes tests of the magnetic properties of iron. Training is given in the handling of dynamo machines, both generators and motors, and in the principal methods of testing these.

In immediate connection with the laboratory courses under consideration, several extended courses of lectures are given. One of these is devoted to the theory and use of electrical measuring instruments, a second to the processes of photometry, and a third to the methods of testing dynamo-electric machinery.

Excursions. — In connection with the lecture and laboratory instruction of the fourth year, it is customary for the class, under the guidance of an instructor, to visit various typical electric light and power plants and manufactories. The apparatus used in these is explained, and the students are held responsible for the knowledge thus imparted.

THESIS.

During the last term of his course every student who is a candidate for a degree spends a large portion of his time in the preparation of a thesis upon some electrical subject. This is always of the nature of an experimental research, investigation, or test of some kind, and may be either purely scientific or technical in its character. In many cases the results of this work have been of such a character

as to merit publication, and a considerable number of such papers have appeared in scientific and technical journals. A list of the titles of theses in Electrical Engineering and Physics, to be found on a later page, will give an idea of their variety and extent.

A high value is attached to such thesis work. In it the student is placed in the attitude of an independent investigator. He is thrown to a large extent upon his own resources in devising methods of investigation and in finding means of overcoming the difficulties that always arise in original work. The attempt is made to give such individual aid to each student as is necessary to keep him from too great loss of time from using wrong methods of procedure, without, on the other hand, giving him such specific directions as would entirely deprive his work of originality. He thus acquires a knowledge of the patience, care, and time which it is usually necessary to spend upon the experimental solution of any new and untried problem.

ENGINEERING.

The Engineering subjects pursued in Course VI. are as follows:

In the second year is given a course in the principles of mechanism, and the construction of gear-teeth, and this is followed by a course on the mechanism of machine tools. In intimate connection with this, drawings are made illustrating the class-room work, such as the laying out of cams and gear-teeth, and the solution of problems in the transmission of motion by belting. Instruction is also given at the shops in carpentry, in wood turning, and in metal turning.

In the third year the subjects are: —

Applied Mechanics, devoted mainly to a mathematical study of the strength of materials.

Valve Gears.

Thermodynamics and Steam Engineering. — This course includes a detailed study of the principles of Thermodynamics, mathematically treated; a discussion of the properties of gases and vapors, especially steam; of the flow of steam and other fluids, of the steam injector, and of the hot-air engine. All of these topics are treated in such a way as to give the student a good foundation in the principles of thermodynamics, especially as they apply to the steam engine. This

is followed by a study of the steam engine itself, of the compound and multiple-expansion engine, and of the mode of testing steam engines; the remainder of the course being devoted to a study of steam-boilers.

The value, to an electrical engineer, of theoretical and experimental training in steam-engineering and allied branches, is obvious upon a consideration of the fact that in the planning and management of an electric light or power plant, the boilers and steam-engines form an element equally important with the dynamos themselves.

Drawing. — The course includes detailed drawings, from measurement, of portions of machines, and of some entire machines; besides the working out of valve gears.

Engineering Laboratory Work. — This is given during the second term, and is devoted to drill in steam-engine tests, for which the 9 in., 16 in., and 24 x 30 in., Allis triple-expansion engine, and also the 8 x 24in. Harris-Corliss engine are used. In these engine tests the water consumption is determined by condensing and weighing the steam after it has passed through the engine.

Fourth Year Engineering. — In the fourth year the following Engineering subjects are pursued: —

Applied Mechanics. — The earlier work in this subject aims to familiarize the students with such data on the strength of materials used in construction as have been obtained by means of experiments, especially those made on a practical scale in different parts of the world. Pains is taken to keep this work well up to date. This is followed by a study of friction and lubrication, of continuous girders, of stone and iron arches, and of the theory of elasticity. Besides the above, each student makes laboratory tests to determine the modulus of elasticity, limit of elasticity, and tensile strength of iron and steel, tests of the deflection and transverse strength of a full-sized beam of wood, tests of wire, of shearing stress, and of the tensile and compressive strength of cements.

Steam Engineering. — A careful study is made of such data as have been based on reliable tests made on large single, compound, and multiple-expansion engines in different parts of the world. The gas-engine is studied, also air compressors and refrigerating machines.

Hydraulics. — The main principles of hydraulics are taught, in-

cluding the flow of water through orifices and pipes and over weirs. A knowledge of these is important to the electrical engineer in view of the frequent application of water-power to the driving of electrical machinery and the increasing importance of the electrical transmission of power from localities in which there is an abundant head of water to distant places where water-power is absent.

A course is also given which treats of Dynamometers, Planimeters, Governors, and Fly-wheels.

Engineering Laboratory Work. — This includes, among other subjects, tests of steam-pumps of different kinds, boiler tests, tests of condensers, steam and hot-air engines, turbines, and the use of power dynamometers of various forms.

COMBINATION OF COURSES AND ADVANCED STUDY.

The continually increasing specialization of the various engineering professions and the upward tendency of the standards of professional attainment render it difficult to give, in a four-year course, much more than a thorough training in the student's chosen specialty. It is thus frequently of great advantage to the graduate from one of the engineering courses to devote an additional year to the professional work of another closely related course, with or without reference to obtaining the degree in the latter. For example, a student who has received a degree in the department of Mechanical Engineering may, by devoting a year to the study of theoretical and practical electricity, graduate in the department of Electrical Engineering; a graduate in Chemical Engineering may do the same; or a graduate in Electrical Engineering or Chemical Engineering may, by a year of additional study, take the degree in Mechanical Engineering.

The student who completes such a double course has obtained a broader scientific and professional education, is enabled to consider a given problem from more than one side, and is thus more efficient and independent in engineering practice.

In order to provide for the needs of students seeking instruction in Electrical Engineering beyond that given in the undergraduate course, an advanced course has also been planned, with provision for the further study of the Mathematical Theory of Electricity, of

Analytical and Applied Mechanics, including the Theory of Rigid Bodies and Hydrodynamics, and also of advanced mathematics.

SPECIAL LECTURERS.

A list of those officers of instruction of the Institute who are particularly connected with the professional work of the Course in Electrical Engineering will be found upon a later page. Special attention is called to the fact that the regular staff of instruction of the department are aided in their work to a very considerable extent by a number of gentlemen actively employed in the practice of the various branches of electrical engineering, who, as "lecturers for the current year," from time to time give courses of lectures of greater or less extent upon the details of those portions of the field with which they are especially familiar. Some of these courses consist of as many as ten or twelve lectures. In other cases only a single lecture may be given. The longer courses are given statedly year after year, while the shorter ones, and especially the single lectures, are varied according to circumstances. These lectures are not intended to give merely popular or general instruction. On the contrary, they are of a highly technical character. They are delivered by men who are familiar with the course of instruction and who understand precisely the stage of advancement reached by the student at the time when the course is given. In fact the majority of those who have thus put their valuable experience at the service of the Department have been former students of the Institute.

The value of such instruction, coming in fresh from the outside world, can hardly be exaggerated. The professional man tells the student precisely what he is doing to-day, as distinct from that which he did yesterday, and why he has made the change. He discusses critically the various methods by which the means at the command of the electrical engineer can be adapted to meet the exigencies which arise under particular and peculiar circumstances. Furthermore, and, perhaps, most important of all, he leads the student to look at the special questions presented, in their relation to systems of working as a whole, rather than as isolated problems which are to be solved by the application of some special formula. Again the realization by the student that the active professional

man is making constant use of the training and information which only a few years before he had himself acquired, perhaps in the same lecture-room, has a highly beneficial effect. The frequent contact with men who are themselves daily aiding in the solution of new problems is in itself calculated to be a source of inspiration. From this work the intelligent student learns to look at things in a large way so as to be ready to take his place among men a short time later when his own school instruction is ended.

Among the courses of this class the following should be particularly mentioned.

(*a*). *The Applications of Electricity to Railway Working.* — These lectures are attended by certain of the students of Civil Engineering as well as by those of Course VI. They comprehend an extended consideration of the various electrical devices used for securing safety in operating a railroad. The different systems of signals are considered and compared with one another. They are illustrated by a model railway which operates a system of the signals actually employed in practice. Through the kindness of the Union Switch and Signal Company, the Hall Signal Company, and the Pennsylvania Steel Company, the Institute is supplied with a full set of the apparatus now in use upon our best railroads. The operation of the systems of signals upon railroads in the vicinity of Boston is also studied upon the ground.

(*b*) *The Distribution of Electricity for Commercial Purposes.* — In this course are discussed the theory and the practice of the methods now in use for the economical supply of electricity for commercial purposes. Both the larger problems of distribution from the central station to the consumer, and the special methods for wiring separate buildings are considered at length. In immediate connection with this course, several special lectures are generally given upon particular systems of distribution, by gentlemen who are professionally concerned with these. Also in this connection the subject of the relation of the industrial uses of electricity to fire and fire risks is considered.

(*c*) *Telephone Engineering.* — This course is devoted to a consideration of the construction of telephone lines both overhead and underground. The different forms of cables and conduits are considered and compared, as well as the various methods of avoid-

ing telephonic disturbances, together with the different standard arrangements employed in central offices.

(*d*) *The Construction and Applications of Electro-Motors.* — In this course the different types of electro-motors are considered minutely, and the special circumstances under which each is preferable are explained. Particular attention is also devoted to recent work in connection with long-distance transmission of power. In immediate relation to this course, several lectures have usually been delivered by different persons upon particular problems connected with the general subject.

(*e*) *The Design of Dynamo Machines.* — In these lectures are considered the special problems that arise in designing different types of dynamo, both direct current and alternating, and for arc or incandescent lighting. The necessary calculations are considered in their application to particular machines.

The single lectures vary from year to year according to the engagements of those who would naturally be invited to instruct the students.

During the school year, 1892–93, the lecturers were as follows: —

Mr. George W. Blodgett, electrician of the Boston & Albany Railroad, on the "Application of Electricity to Railway Working"; Mr. Hammond V. Hayes, of the American Bell Telephone Co., on "Telephone Engineering"; Mr. William W. Jacques, of the American Bell Telephone Co., on "Cable Telephony"; Mr. Cyrus A. George, of the Boston Municipal Fire Alarm Telegraph, on "Municipal Fire Alarm Systems"; Mr. Anthony C. White, of the American Bell Telephone Co., on the "Distribution of Electricity for Commercial Purposes"; Mr. C. J. H. Woodbury, of the Manufacturers' Mutual Fire Insurance Company, on "Electric Lighting in Connection with Fire Risks"; Mr. Jonathan P. B. Fiske, of the General Electric Co., on the "Construction and Applications of Electro-motors"; Mr. Horace F. Parshall, of the General Electric Co., on the "Designing of Dynamos"; Mr. Maxwell Day, of the General Electric Co., on the "Thomson-Houston System of Arc Lighting"; Mr. J. E. Randall, of the General Electric Co., on the "Manufacture of Incandescent Lamps"; Mr. Walter S. Moody, of the General Electric Co., on "Alternating Current Apparatus."

SOCIETY OF ARTS AND ELECTRICAL CLUB.

In addition to the lectures which are delivered especially for the benefit of the students in Electrical Engineering, in the course of every winter there are papers read before the Society of Arts of the Institute upon electrical engineering and allied subjects which are of great value. The meetings of this society are always open to the students.

During the school year, 1892–93, the following physical, electrical and engineering subjects were presented: —

"The Standards of Weight and Length of the United States," by Prof. T. C. Mendenhall, Superintendent of the United States Coast and Geodetic Survey; "Lightning and Strong Current Protectors for Telephones," by Mr. I. H. Farnham, Electrician of the New England Telephone and Telegraph Company; "The Heating and Working of Metals by Electricity," by Mr. G. T. Burton, President of the Electrical Forging and Welding Co.; "The Course in Naval Architecture at the Massachusetts Institute of Technology," by Prof. C. H. Peabody, of the Institute; "The Manufacture of Heavy Ordnance in the United States," by Lieut. W. H. Jacques, Ordnance Engineer of South Bethlehem, Pa.; "Fire-Proof Construction," by Mr. H. Poulson, of the Hecla Iron Works, N. Y.; "High Frequency Electric Induction," by Prof. Elihu Thomson; "The Action of Compound Dynamos when run in Parallel," by Mr. Wm. L. Puffer, of the Institute; "Fire Hazard of Electricity," by Mr. Wm. Brophy, of the Massachusetts Manufacturers' Mutual Fire Insurance Co.; "Account of some recent investigations in Acoustics made in the Rogers Laboratory of Physics," by Prof. C. R. Cross, of the Institute; "The Blower System of Heating and Ventilation," by Mr. W. B. Snow, of the Sturtevant Blower Company.

The Electrical Club of the Institute offers to the students an opportunity of practice in the preparation and public presentation of papers on scientific and professional subjects. Its meetings occur once in each month of the school year. The apparatus of the department is put at the service of the young men who desire it for the purpose of illustrating their papers.

Rooms and Equipment of the Departments of Physics and Engineering.

ROGERS LABORATORY OF PHYSICS.

The work in Physics and Electricity is carried on in the Rogers Laboratory of Physics, which is so-called in recognition of the work of Professor William Barton Rogers, the founder and first president of the Massachusetts Institute of Technology, who originated the plan of systematic laboratory instruction in Physics to students in classes.

The laboratory is located in the Walker Building and comprises seventeen rooms, of which the following * are the principal ones: —

Lecture Rooms. — General Physical Lecture Room, second floor, No. 22, 44½ x 39⅓ ft. in area, and seating two hundred and seventy students. This room is supplied with two independent circuits of electricity from the dynamo-room, so that alternating and direct currents can be used simultaneously if desired. There is, besides these, the general lighting circuit on which the lamps illuminating the rooms are placed. These circuits can be connected at will, either with the dynamos belonging to the plant of the department, or with the mains of the Edison Electric Illuminating Company which are connected with the Walker Building. The lecture table is furnished with water, gas, blast and vacuum pipes and a *porte-lumière* can be placed at the west window. There are facilities for the use of the lime and electric lights for lantern projections.

Lecture room for special lectures in Physics and Chemistry, second floor, No. 23, 35 x 25 ft., seating seventy students, and provided with the usual facilities for physical and chemical demonstration.

Laboratory Rooms. — The Laboratory of General Physics, first floor, No. 16, 108 x 29½ ft., is devoted to instruction in general physical measurements, as, for example, the use of instruments for the determination of lengths and volumes, of specific gravity, temperature, specific and latent heat, together with meteorological instruments, the microscope and the spectroscope, and also apparatus for the simpler electrical measurements. It contains two dark rooms fitted up for photometric measurements.

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* The numbers refer to the plans of the Walker and Engineering buildings to be found on pp. 41–45 of this pamphlet.

The Acoustic Laboratory, No. 25A (second floor), 33 x 29½ feet. This laboratory is especially designed for acoustic and telephonic study and research. It is furnished with special telephone and electric light and power circuits, and a special blast of constant pressure. There are electro-motors and all other needed facilities for the electrical driving of sirens and like machinery.

The extensive collection of acoustic apparatus for demonstration and research possessed by the Institute finds a place in this room.

The Optical Room, No. 25B, 29½ x 29 feet. In this will be carried on any work of such character as to require the use of sunlight, for which it is well adapted as it opens toward the east and south. The cabinet of optical apparatus is placed herein.

No. 25C (second floor), 16 x 14 feet, is a private study.

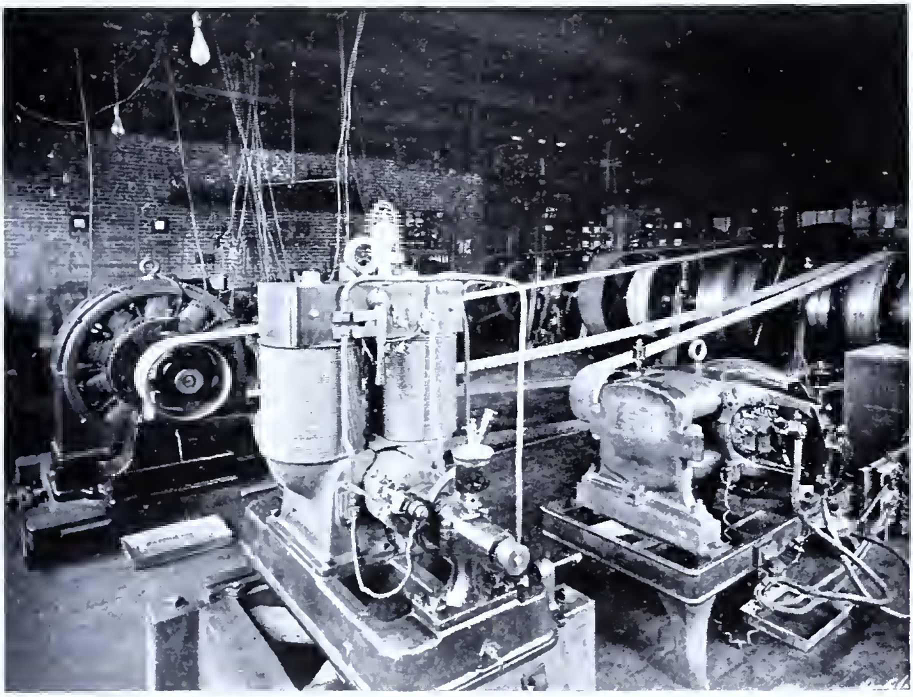
No. 23A (second floor), 39 x 14 feet, is a room devoted to special work of research as occasion may require. It is also used during a portion of the year by the chemical department for instruction in optical saccharimetry.

The Laboratory of Electrical Measurements, first floor, No. 10, 108 x 29½ ft. This room is especially arranged for work in electricity. It is furnished with special electric circuits for lighting and power and for both direct and alternating currents. It contains apparatus for the accurate measurement of the resistance of conductors, the insulation resistance of cables, the capacity of condensers, the calibration of ammeters, voltmeters, and other current and potential measuring instruments, apparatus for investigating the magnetic properties of iron, and for various other electrical tests. Much of this apparatus is original in design, and care is taken to adopt those instruments and methods which are of the greatest value and reliability in scientific and technical work.

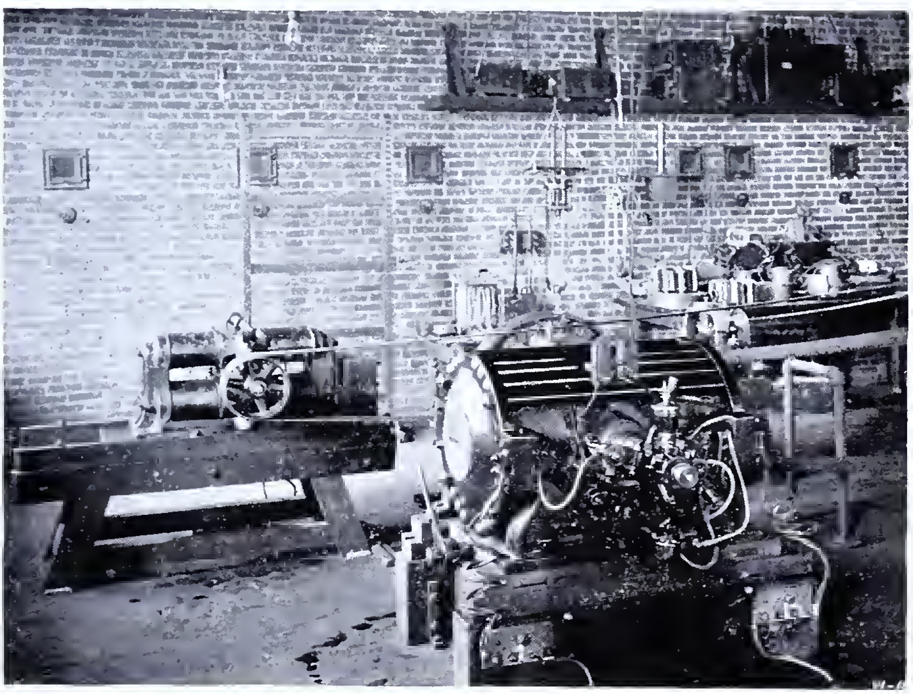
From this room opens the office of the department, No. 11, a room 39½ x 22½ ft. in area.

Also on the same floor, No. 13, is an apparatus room, 39½ x 15½ft.

The Dynamo Room, No. 4, is located in the basement. It is 40 x 40 ft. in area, and contains the plant of dynamos of the department. A 75 h. p. Westinghouse engine furnishes the motive power for driving these. The principal generators permanently placed here are the following: a 150-light Edison machine, given



THOMSON-HOUSTON ALTERNATOR.
EDISON MACHINE AND UNITED STATES LOW VOLTAGE MACHINE.



WESTON AND THOMSON-HOUSTON MACHINES.

to the Institute by Mr. Thomas A. Edison; a 200-light Thomson-Houston constant potential machine, the gift of the Thomson-Houston Electric Company; a 60-light Weston incandescent machine, a 500-light Thomson-Houston alternating machine, and a United States 300-ampere low voltage machine for use in electrolysis. Besides these, from time to time other machines loaned to the department are employed for purposes of study and testing. Among such at present in use, and kindly lent by the makers or others are two Thomson-Houston 15 h. p. dynamos of the motor type, a Siemens alternating current arc-light machine with exciter, a 30 arc-light Brush machine; two Thomson-Houston railway motors, and a Thomson-Houston 7½ h. p. upright motor. Of smaller machines, generators and motors, the department possesses a large number, of which the following are worthy of mention: an Eddy 1 h. p. dynamo, a small Gramme 1 h. p. dynamo, a Brush 3 arc-light dynamo, a Weston 1½ h. p. dynamo, two Sprague motors of 2 h. p., and 5 h. p., respectively, and a 5 h. p. compound dynamo constructed in the laboratory, together with various others of smaller capacity. Also the United States 500-light compound dynamo in the Engineering Building is utilized for purposes of instruction. The plant of dynamos in the Physical Laboratory is wholly available at all times for purposes of instruction, since the lighting circuits of the Institute can all be connected at will with the mains of the local Edison Illuminating Company. The current from the latter is habitually used whenever the needs of the laboratory call for the total output of its own dynamos, or whenever the use of these for lighting in any way interferes with their use in tests.

The Laboratories of Electrical Engineering, No. 4A, 36½ x 29 ft., No. 2, 61½ x 29½ ft., and No. 6, 83⅓ x 29½ ft., are also located in the basement, and are devoted especially to study and research relating to technical electricity, though certain other work also finds a place therein at present.

No. 4A is set aside for such thesis work as may conveniently be carried on there. No. 6 contains a cradle dynamometer, an ice calorimeter for testing transformers, a closed room for testing ventilating fans, and a five hundred volt storage battery for purposes of calibration. In it are also placed two photometric rooms especially fitted up for measurements of arc and incandescent lights. A por-

tion of the room is set aside as a workshop for the mechanician of the department, to which the students also have access.

No. 2 contains storage batteries and various miscellaneous electrical apparatus. A portion of the room is also used for purposes of instruction in heat measurements. Two dark rooms for photographic purposes and a third for electrical or other work requiring darkness are also located here.

No. 25C (on the second floor) is a room for the adjustment and testing of resistance coils, 23 x 10 feet. Here are found the standard Wheatstone's Bridge and constant temperature tank, together with the needed galvanometers and other apparatus for accurate work of this character.

No. 25D (second floor) is a room for Inductance Measurements 16 x 15½ feet. This contains electro-dynamometers, a secohmmeter, a standard of self-induction and like instruments used in measuring inductance. For such work the department possesses two dynamos designed by one of its instructors which are especially intended to produce a rigorously sinusoidal current.

The Rogers Laboratory has an exceedingly extensive equipment of apparatus for both demonstration and physical measurements, and large additions are made to it every year. It is not lacking in any instruments needed for electrical measurements and testing, and the more important of these are duplicated to a great extent to meet the needs of the large classes of students.

Library. — The Physical Library, No. 14 (first floor), 39½ x 37½ ft., contains 3,600 volumes and 800 pamphlets, and is very complete in recent works upon physics and electricity. All new publications of importance are procured upon their issue. The principal physical and electro-technical periodicals are received regularly, fifty such being taken. Various others bearing more or less closely upon the work of this department are to be found in the Chemical and Engineering Libraries, numbering 5,500 and 4,500 volumes respectively. The total number of volumes in the Library of the Institute is 29,000 and the number of periodicals currently received is 450. Besides this the students have free access to the Boston Public Library, numbering over 500,000 volumes, and also by the courtesy of the owners, to the libraries of various learned societies and private individuals.

THE ENGINEERING LABORATORIES.

The objects to be accomplished by these laboratories are the following: first, to give the students practice in such experimental work as engineers in the pursuit of their profession are called upon to perform; second, to afford some experience in carrying on original investigations in engineering subjects, with such care and accuracy as to render the results of real value to the engineering community; third, by publishing, from time to time, the results of such investigations, to add gradually to the common stock of knowledge. These laboratories are situated in the Engineering Building, where they occupy the two lower floors, 50 by 150 feet each.

Applied Mechanics Laboratory. — The laboratory for testing the strength of materials, basement No. 2, and first floor No. 10B, is furnished with the following apparatus: an Olsen testing machine of fifty thousand pounds capacity, for determining tensile strength, elasticity, and compressive strength; a testing machine of the same capacity for determining the transverse strength and stiffness of beams up to twenty-five feet in length, and of framing joints used in practice; machinery for the measurement of the twist of shafting; for testing the tensile strength of mortars and cements, and of ropes; for testing the effect of repeated stresses upon the elasticity and strength of iron and steel; for determining the strength and elasticity of wire; for determining the deflection of parallel rods when running under different conditions; also accessory apparatus for measuring stretch, deflection, and twist. Besides the above stated apparatus, a horizontal Emery testing machine of 300,000 pounds capacity has recently been constructed for this laboratory by William Sellers & Co., of Philadelphia. It contains all the essential features of the 800,000 pounds testing machine at the Watertown arsenal, built by Lieut. Albert H. Emery. The new machine is suitable for testing a compression specimen eighteen feet long, and a tension specimen twelve feet long.

Hydraulic Laboratory. — The hydraulic laboratory, basement No. 1, and first floor, No. 10A, contains a closed steel tank five feet in diameter and over twenty-seven feet high, arranged for the insertion of orifices, mouthpieces, and other special pieces of apparatus, with

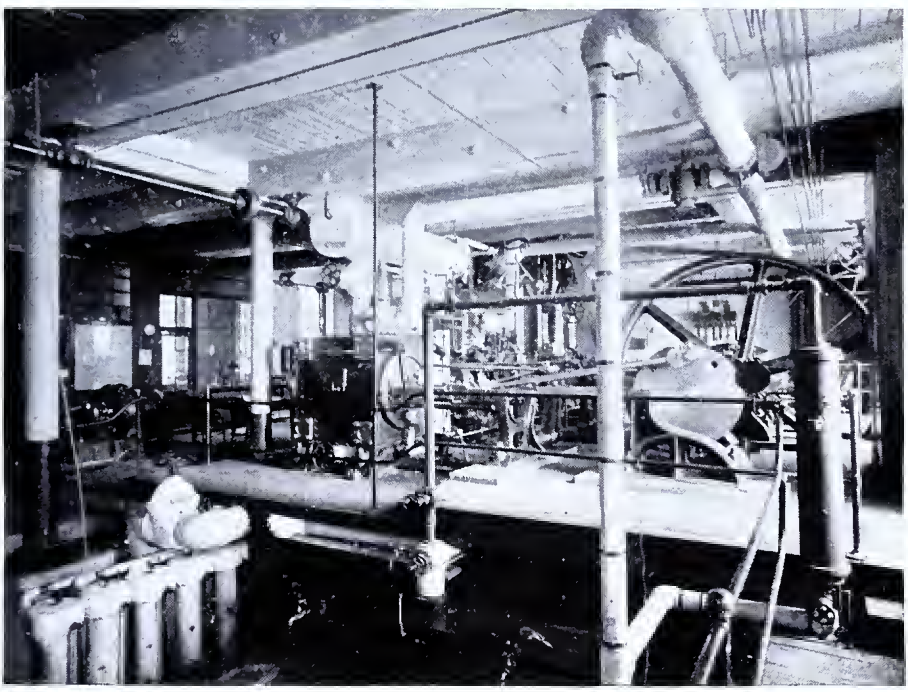
gates for controlling the discharge, and with connections for supplying water, in experiments upon pipes and motors. This tank is connected with a ten-inch standpipe over seventy feet high, so arranged that a constant head may be maintained at any desired level. A steel tank of about 280 cubic feet capacity gives opportunity for the accurate measurement of larger quantities of water than can be weighed directly during experiments. A system of pipes, connected both with the main tank and with the pumps, is fitted for the insertion of diaphragms, branches, and other apparatus for studying loss of head and the laws of discharge. An attachment has been fitted to the main tank, containing a Pitot tube, for studying the laws of velocity in jets and adjustable points for accurate measurement of the cross-section of jets. The laboratory is further equipped with a variety of mercury gauges, weirs, standard orifices, mouthpieces, diaphragms, branches, nozzles, etc., for experiments with flowing water under all conditions. A six-inch turbine is arranged to be run under various conditions of head and gate opening in tests for efficiency.

Laboratory of Steam Engineering. — The steam laboratory, basement, No. 1, contains a triple expansion engine, with cylinders of 9 inches, 16 inches, and 24 inches diameter respectively, and 30 inches stroke, arranged in such a way as to be run single, compound, or triple, as desired for the purposes of experiment. This engine is of the Corliss type, and has a capacity of about 150 horse-power when running triple, with an initial pressure of 150 pounds in the high-pressure cylinder. It is connected with a surface condenser and the other apparatus necessary to adapt it to the purposes of accurate experiment.

This laboratory also contains a 16 horse-power Harris-Corliss engine, and an 8 horse-power engine, used for giving instruction in valve setting, etc. It is equipped with several surface condensers, steam-pumps, calorimeters, mercurial pressure and vacuum columns; apparatus for determining the quantity of steam issuing from a given orifice or through a short tube under a given difference of pressure; apparatus for testing injectors; and with indicators, planimeters, gauges, thermometers, anemometers, and other accessory apparatus.

The engineering laboratories are provided with a number of friction-brakes; with machinery for determining the tension required

LABORATORY OF ELECTRICAL MEASUREMENTS.
(See page 22.)



TRIPLE EXPANSION ENGINE.

in a belt or rope to enable it to carry a given power, at a given speed, with no more than a given amount of slip; with three transmission dynamometers; also with a complete set of Westinghouse air-brake apparatus, including the parts belonging to the car and to the locomotive; the pump and engineer's valve of the New York air-brake: an 8-inch, a 12-inch, and a 48-inch weir for measuring water, and an orifice for the same purpose; a locomotive link model; a centrifugal pump and a rotary pump; a hot-air engine; a pulsometer. There are available for the purposes of experiment, in connection with the work of these laboratories, a horizontal tubular boiler, and two large sectional boilers situated in the Rogers Building; also another boiler, a 40 horse-power Brown engine, and other apparatus in the workshops on Garrison Street.

The Workshops. — Practical instruction in the nature of the materials of construction, and in the typical operations involved in the arts, is considered a very valuable adjunct to the theoretical treatment of professional subjects. Workshops have been provided and furnished with the more important hand and machine tools, so that the student may acquire a direct knowledge of the nature of metals and woods, some manual skill in the use of tools, and a thorough knowledge of what can be accomplished with them. The shops are located on Garrison Street, and are equipped as follows:—

The carpentry, wood-turning, and pattern-making departments contain 40 carpenter's benches, 2 circular saw benches, a swing saw, 2 jig saws, a buzz-planer, a mortising machine, 36 wood-lathes, a large pattern-maker's lathe, and 36 pattern-maker's benches. The foundry contains a cupola furnace for melting iron, 2 brass furnaces, a core oven, and 32 moulder's benches. The forge shop contains 32 forges, 7 blacksmith's vises, and 1 blacksmith's hand drill. The machine shop contains 23 engine lathes and 17 hand lathes of approved patterns, 2 machine drills, 3 planers, a shaping machine, a universal milling machine, a universal grinding machine, and 32 vise benches arranged for instruction in vise work.

THE COURSE IN PHYSICS.

COURSE VIII.

This course, which was instituted in 1873, differs from the course in Electrical Engineering in that it is intended to be distinctly scientific rather than technical in its nature, dealing principally with pure science, and only secondarily with its applications. But, as is proper in a technical school, the student necessarily learns much regarding these, and may if he chooses pursue many of the technical studies.

Course VIII. is especially intended to meet the needs of those who desire to become teachers of Physics and Mathematics, or who wish to pursue a course in pure science, either with a view to its further continuance or wholly as a matter of training. It also offers an opportunity for such persons as desire to prepare themselves to enter upon professional work in any branches of applied electricity in which a knowledge of chemistry rather than of mechanical engineering is desirable.

CHARACTERISTICS OF THE COURSE.

As will be seen on reading the scheme of studies, the leading features of this course are a thorough and continuous study of the various branches of physics and a treatment of mathematics considerably advanced beyond the requirements of any of the technical courses. General, theoretical, analytical, and organic chemistry occupy a position next in prominence to mathematics, and of hardly less importance. Every candidate for a degree is required to pursue courses in both mathematics and chemistry through the first three years of the course ; and also, during the greater part of the last three years, in addition to the required studies in these subjects must select an option involving further work in one of them.

SCHEDULE OF STUDIES

IN THE COURSE IN PHYSICS.

FIRST YEAR.

First Term. (*Common to all Courses.*)

Solid Geometry.
Algebra.
General Chemistry.
Chemical Laboratory.
Rhetoric and English Composition.
French (or German).
Mechanical Drawing.
Freehand Drawing.
Military Drill.

Second Term.

Plane and Spherical Trigonometry.
General Chemistry: Qualitative Analysis.
Chemical Laboratory.
Political History since 1815.
French (or German).
Mechanical Drawing and Descriptive Geometry.
Freehand Drawing.
Military Drill.

SECOND YEAR.

First Term.

Physics: Mechanics, Wave Motion, Optics (Lectures).
Acoustics.
Analytic Geometry.
Chemical Analysis.
Theoretical Chemistry.
Descriptive Astronomy.
English Literature.
American History.
German (or French).

Second Term.

Physics: Optics, Electricity (Lectures).
Acoustics, Magnetism, Electricity.
Physical Laboratory: General Physical Measurements.
Differential Calculus.
Microscopy.
English Literature and Composition.
German (or French).

Options.

1. Chemistry: Quantitative Analysis.
2. General Theory of Equations; Determinants.

THIRD YEAR.

First Term.

Physics: Heat (Lectures).
Physical Laboratory: General Physical Measurements.
Optics or Electricity.
Integral Calculus.
Differential Equations.
Elements of Organic Chemistry.
Political Economy.
Business Law.
German (or French).

Options.

1. Physiology of the Senses.
2. Shopwork.
3. Quantitative Analysis.
4. Quaternions.

Second Term.

Physical Laboratory: Heat and Electrical Measurements.
Optics, Electricity, or Heat.
Analytical Mechanics.
Theoretical Chemistry.
Political Economy and Industrial History.
Business Law.
German (or French).

Options.

1. Quantitative Analysis.
2. Analytical Geometry of Three Dimensions; Advanced Calculus and Definite Integrals.

FOURTH YEAR.

First Term.

Physical Laboratory: Electrical Testing.
Experimental or Mathematical Physics.
Mathematical Electricity.
Memoirs.
Analytical Mechanics.
Thermodynamics.
Photometry.
Least Squares.
History of Science.

Options.

1. Organic Chemistry.
2. Fourier's Series; La Place's Coefficients.

Second Term.

Physical Research: Thesis.
Experimental or Mathematical Physics.
Discussion of the Precision of Measurements.
Analytical Mechanics.
Principles of Scientific Investigation.

Options.

1. Physiological Measurements.
2. Fourier's Series; La Place's Coefficients.
3. Mathematical Electricity.
4. Physical Research.

A comparison of the schemes of study for the two courses will show that Course VIII. differs from Course VI. chiefly in the following particulars : —

(1.) The engineering studies which necessarily occupy so prominent a place in the latter course, in the former are replaced by chemistry and pure and applied mathematics. The subject of differential equations is brought into the course in the first term of the third year ; and upon its close is begun a course in analytical mechanics which extends through the whole fourth year, this subject replacing the applied mechanics and engineering of Course VI.

If he chooses the mathematical option in addition to the required studies in mathematics, the student takes successively courses in quaternions, analytical geometry of three dimensions, advanced calculus, and definite integrals, Fourier's series and La Place's coefficients.

The instruction in thermo-dynamics is also specially planned to meet the needs of the physicist rather than the engineer.

The necessity of a thorough knowledge of mathematics and the exceedingly great advantage of a good chemical training to one intending to teach physics or to pursue more advanced courses in that subject is obvious. All physics rests upon a mathematical foundation, and the demands upon the physicist in this direction are daily becoming greater. Moreover, various branches of physical chemistry are rapidly assuming extreme importance.

(2.) There is much flexibility in the course as to the particular branches of physics which may be pursued by one studying for the degree. The general courses of lectures and laboratory work in physics in the second and third year are required of all, but beyond these the student has a large liberty of choice. He may devote himself particularly to optics, electricity, or heat throughout the greater part of the third and fourth years. Or, if he desires, he may take the different courses in technical electricity in common with the students in Electrical Engineering. Within reasonable limits he may also devote himself either to mathematical or experimental work in these subjects.

(3.) There are various courses of greater or less length which are introduced especially to broaden the training or information of the student. Such, for example, are microscopy, the physiology of the

senses, which is an alternative with shopwork, the history of science and a study of the logical principles of scientific investigation. Also in the latter part of his course each student prepares and reads before his class an essay on some physical topic. These essays are written after a study of recently published papers and memoirs, and often embody also the results of experimental work by the student. They are intended to familiarize the class with the topics presented, and to give experience in independent study and in the preparation of original scientific papers.

Instruction is also provided in photography and in the use of the lantern as an instrument of demonstration in the lecture room.

The course in physics is not intended to be easy or adapted to immature minds. But it affords to competent students a very thorough training in science, and it has been found to furnish an excellent preparation either for teaching or for more advanced study.

THESES.

The following is a list of theses upon physical subjects written chiefly by candidates for a degree in the courses in Physics and Electrical Engineering: —

1870.

Focal Length of Microscopic Objectives. — C. R. Cross.

1875.

A Study of the Operation of the Holtz Machine. — S. J. Mixter.

1876

The Mean Specific Gravity of the Earth. — J. B. Henck, Jr.
Experiments on the Viscosity of Air. — S. W. Holman.
New Experiments on Sound. — W. W. Jacques.

1879.

The Colors of our Common Lights. — W. H. Pickering.

1880.

A History of Musical Pitch and its Present Condition in Boston. — W. T. Miller.

1882.

A Study of Alcohol Thermometers at Low Temperatures. — A. C. White.

1885.

Telephonic Studies. — W. J. Hopkins.
The Measurement of the Strength of Telephone Currents. — J. Page.
Electro-motors and their Efficiency. — F. A. Pickernell and H. G. Pratt.
Measurement of Strong Currents and High Electromotive Forces. — R. H. Pierce.

1886.

The Electrical Transmission of Power. — D. P. Bartlett and H. E. Clifford.
An Experimental Study of a Weston Dynamo. — W. L. Church and C. M. Wilder.
Compound Winding of Dynamos. — F. H. Crane and H. P. Merriam.

Tests of a Commercial Storage Battery. — E. E. HIGGINS.
Measurement of the Strength of Telephone Currents, with some Special Experiments on Blake Contacts. — W. J. HOPKINS.
The Effect of Metal Screens on Electrodynamic Induction. — F. LEWIS.
The Inverse Electromotive Force of the Voltaic Arc. — W. E. SHEPARD.
Researches in Relation to Cable Telephony. — THEODORE STEBBINS.

1887.

Efficiency Test of a Thomson-Houston Dynamo. — W. C. FISH and G. F. CURTISS.
The Inverse Electromotive Force of the Voltaic Arc. — J. M. FOX.
A Study of the Deviation between the Mercurial and the Air Thermometer. — W. S. HADAWAY, Jr.
Comparison of Old and New Brush Armatures. — W. S. MOODY and J. T. WHITNEY.
Researches Relating to the Melting Platinum Standard of Light. — H. D. SEARS and G. TAINTOR.
Experiments on the Blake Transmitter. — G. W. PATTERSON and H. J. TUCKER.
The Effect of Projecting Teeth in Armatures — RALPH VOSE.
A Study of the Efficiency of Incandescent Lamps. — W. G. WHITMORE and E. R. PEARSON.

1888.

Commercial Efficiency of a Weston Motor under Various Loads. — J. C. T. BALDWIN and W. H. BLOOD, Jr.
The Relation of Increase of Illuminating Power to Increase of Current and Energy Consumed in Incandescent Lights. — D. A. CENTER and L. A. FERGUSON.
A Study of Commercial Storage Batteries. — G. E. CLAFLIN and E. F. DUTTON.
The Efficiency of Various Incandescent Lamps. — S. H. COBB and G. B. POOL.
The Influence of Metal Screens on Electromagnetic Induction. — EDWARD COLLINS, Jr.
An Experimental Study of Harcourt's Pentane Lamp and Some Other Standards of Light. — S. C. HATHAWAY, Jr., and E. R. PEARSON.
A Study of the Motion of the Electrodes of a Microphone Transmitter. — A. W. JONES.
The Distribution of Potential around the Collectors of Dynamo Machines. — C. A. PETERSON and W. I. TOWNE.
The Inverse Electromotive Force of the Voltaic Arc. — RUSSELL ROBB and H. W. BLAKE.
The Strength of Current Produced by the Microphone as Determined by Pressure and Material of the Electrodes. — ANNIE W. SABINE.
A Study of Specific Inductive Capacity, with Different Rates of Charge. — F. H. SAFFORD and G U. G. HOLMAN.

Efficiency of Alternating Current Transformers. — C. A. STONE and E. S. WEBSTER.

The Strength of the Induced Current in a Magneto-Telephone as Affected by the Strength of the Magnet. — A. S. WILLIAMS.

1889.

An Experimental Study of a Weston Dynamo Machine. — F. W. BRADLEY and H. H. HUNT.

The Efficiency of Alternating Current Transformers. — J. N. BULKLEY and G. B. LAUDER.

An Investigation of the Motion of the Electrodes of the Microphone Transmitter. — F. L. DAME.

The Efficiency of Alternating Current Transformers as Determined by the Electrometer Method. — J. P. B. FISKE, H. FRENCH, and W. L. SMITH.

The Distribution of Light of Incandescent Lamps, with Efficiency Measurements. — E. W. GANNETT and H. M. HOBART.

A Study of Specific Inductive Capacity with Various Rates of Charge. — G. U. G. HOLMAN.

The Inverse Electromotive Force of the Voltaic Arc. — A. D. KINSMAN and H. P. EDGETT.

Experiments with Induction Coils for Telephone Purposes. — F. A. LAWS.

A Study of the Regulation of the Thomson-Houston Constant-Potential Dynamo. — C. W. PIKE and E. P. WHITNEY.

An Experimental Study of the Efficiency of Commercial Storage Batteries. — C. W. POWER and G. W. ROUNDS.

A Study of the Thomson-Houston Electric Motor. — A. E. TRUESDELL and C. H. WARNER.

1890.

Experiments on Commercial Storage Batteries. — J. B. BAKER and T. J. STURTEVANT.

The Efficiency of Alternating Current Transformers. — J. B. BLOOD, W. L. SMITH, and F. W. SWANTON.

An Experimental Study of the Waste Field of Dynamos. — E. D. BROWN and F. M. GREENLAW.

The Effect of Projecting Teeth in Ring Armatures. — M. CARLISLE and J. CLARK, Jr.

An Experimental Investigation of the Various Methods of Testing Shunt Motors. — F. W. DUNBAR, and M. O. SOUTHWORTH.

Some Experimental Researches in Acoustics. — H. M. GOODWIN.

Photography of the Solar Prominences. — G. E. HALE.

Efficiency Test of a Thomson-Houston Arc Lighting Dynamo. — J. R. HALL and E. B. RAYMOND.

The Influence of the Strength of the Core on the Action of the Magneto-Telephone Transmitter and Receiver. — H. E. Hayes.

An Investigation of the Manner of Decomposition in a Certain Class of Electrolytic Cells. — E. A. Le Sueur.

The Insulation Resistance of Rail Circuits in Railroad Block-Signals. — B. H. Mann.

Efficiency of Induction Coils used in Telephony. — C. Neave.

Tests of Commercial Registering Current Meters. — C. W. Rice.

1891.

Efficiency of Alternating Current Transformers. — T. V. Bolan and F. S. Viele.

An Experimental Study of Induction Coils — H. G. Bradlee and R. W. Conant.

The Safe Carrying Capacity of Copper Wires. — W. H. Brainerd and H. H. Sykes.

The Commercial Efficiency of Small Electro-Motors. — B. Capen, Jr.

Experiments upon Commercial Electric Meters. — A. L. Clough.

Some Tests on the Union Street Railroad, Dover, N. H. — F. H. Dorr and P. W. England.

The Resistance of the Voltaic Arc. — H. H. Ensworth and J. F. White.

Investigation of Stray Power of Edison Dynamos. — C. Garrison and M. W. Greer.

On the Least Number of Vibrations Necessary to Determine Pitch. — Margaret E. Maltby.

The Extent of Motion of the Diaphragm of a Telephone Receiver. — A. N. Mansfield.

Conductivities of Commercial Copper Wires. — W. Mossman.

An Experimental Study of an Edison Dynamo. — G. H. K. Oxford and W. I. Palmer.

A Method of Studying the Motion of the Diaphragm in a Telephone Receiver. — C. W. Ricker and H. H. Wait.

Efficieney Test of the Malden Electric Lighting Station. — F. T. Snyder and T. Spencer.

A Study of the United States Constant Potential Dynamo.— G. H. Spooner and G. M. Warner.

An Acoustic Study of the Blake Transmitter.— H. A. Thompson.

The Experimental Study of an Alternating Current Dynamo by the Air-Calorimeter Method.— L. C. Wason and H. P. Spaulding.

1892.

Relation of the Candle Power of Incandescent Lamps to the Current, Voltage and Energy consumed.— C. A. Beal and C. H. Chase.

Tests upon Street Railway Motors.— C. H. Bigelow and B. P. du Bois.

Tests of the Calorimetric Method of Determining the Efficiency of Alternate Current Transformers.— P. M. Burbank and C. M. Burnham.

Tests of an Alternate Current Motor.— L. P. CODY and E. R. FRENCH.

A Study of the Stray-Power of Thomson-Houston Compound Dynamos.— J. CRANE, Jr., and D. P. ROBINSON.

On the Measurement of Coefficients of Self-Induction.— L. DERR.

Comparative Tests of Ventilating Fans, Including a Discussion of the Electric Motor as a Dynamometer.— H. A. FISKE and H. C. FORBES.

Distribution of Light of Edison and Thomson-Houston Incandescent Lamps.— W. P. GRAY and A. S. HEYWOOD.

Efficiency Test of the Dedham Electric Light Station.— J. D. HILLIARD, Jr. and C. C. WATERMAN.

Tests of an Edison Electric Light Station.— F. J. HOXIE and R. H. MANSFIELD, Jr.

Some Tests on the Brockton Electric Street Railway, Brockton, Mass. — A. L. JACOBS and W. E. MCCAW.

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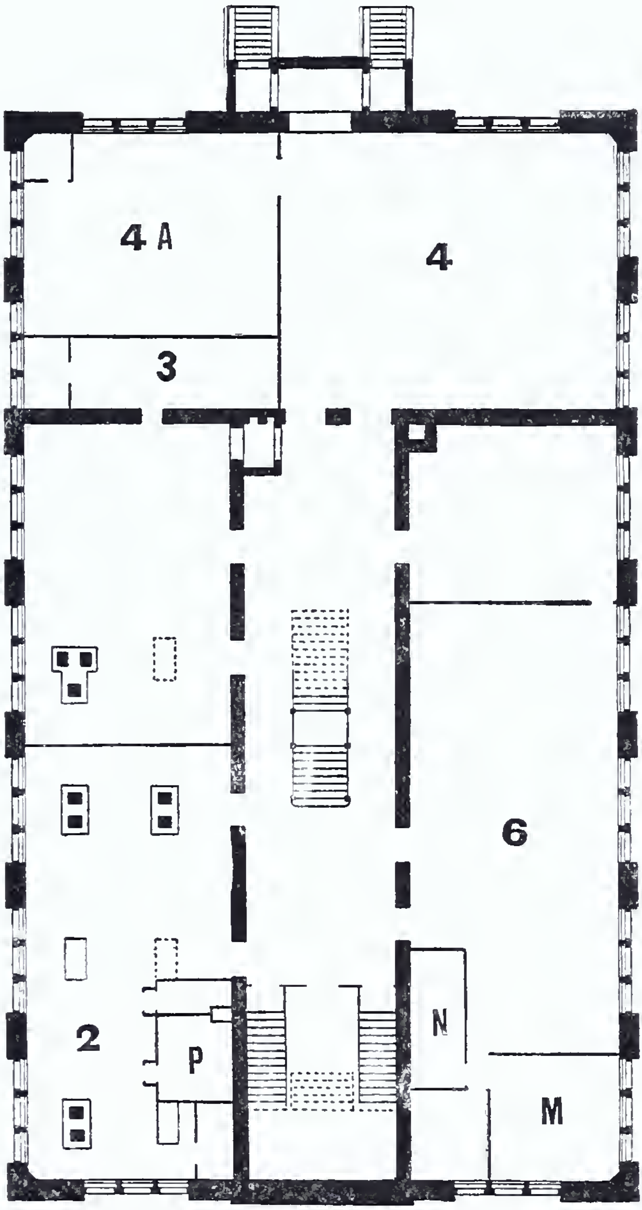
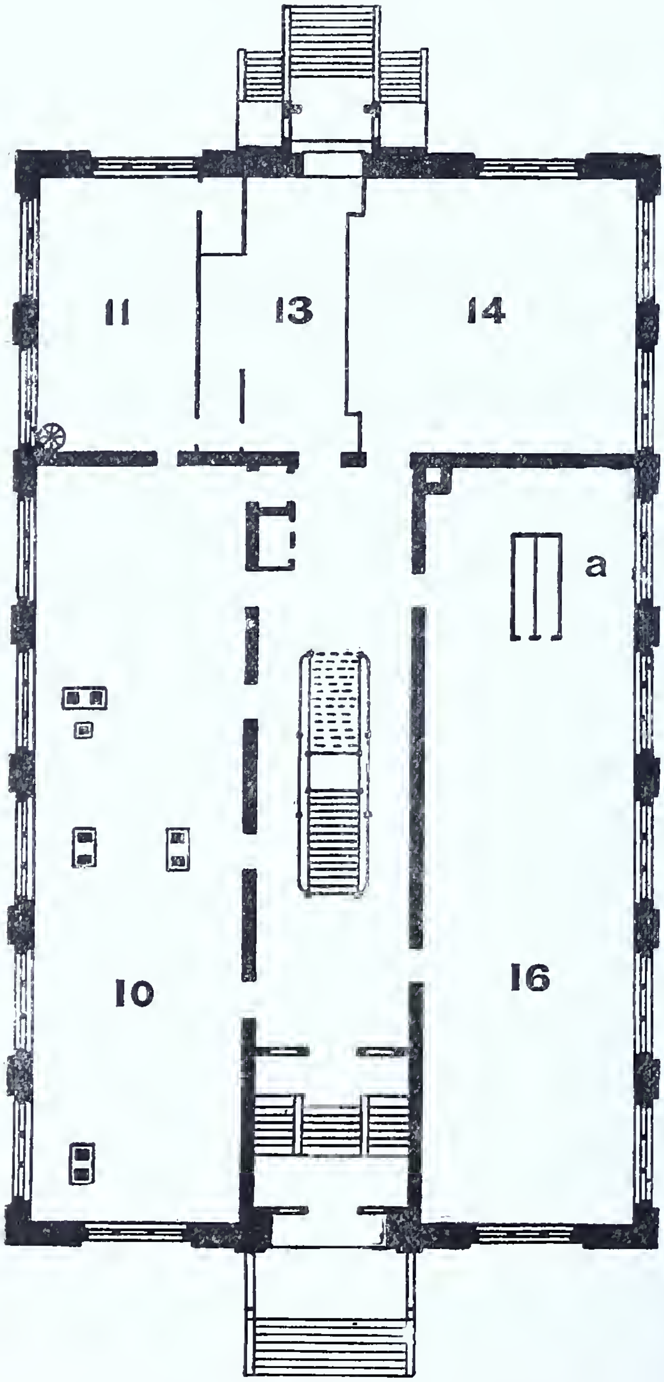
BASEMENT.



2, 4 A, 6, Laboratories of Electrical Engineering. N, Photometer Room. M, Mechanician's Work Shop. P, Photographic Rooms. 4, Dynamo Room.

WALKER BUILDING;

FIRST FLOOR.



10, Laboratory of Electrical Measurements. 11, Office. 13, Apparatus Room. 14, Library. 16, Laboratory of General Physics.

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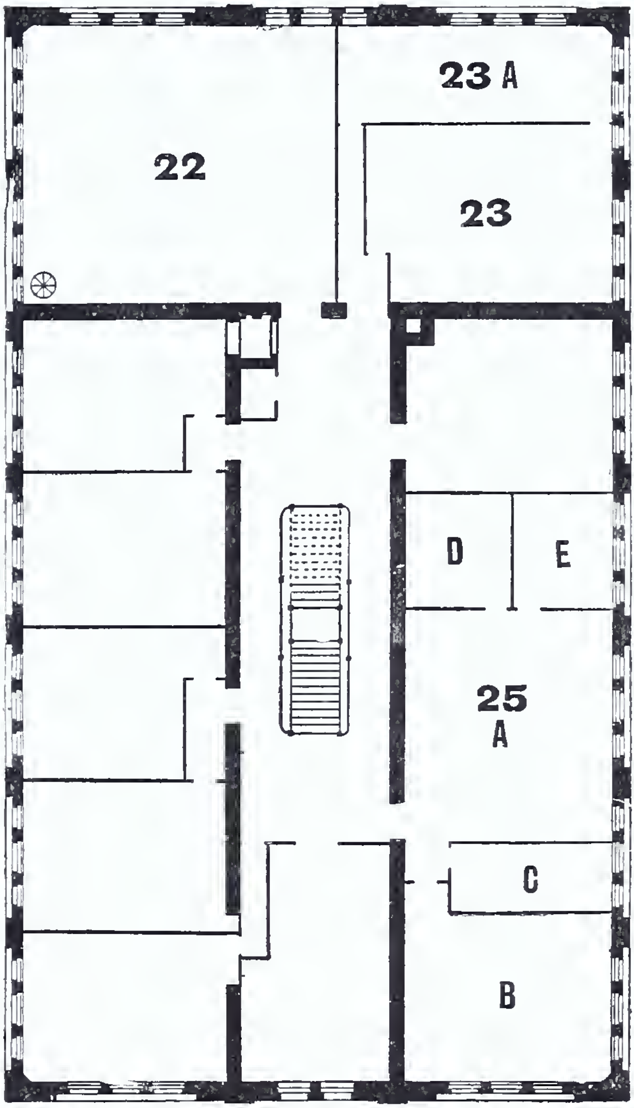

22, 23, Lecture Rooms. 23 A, Laboratory Room. 25 A, Acoustic Laboratory. B, Optical Room. C, D, Electrical Rooms. E, Study.

ENGINEERING BUILDING;

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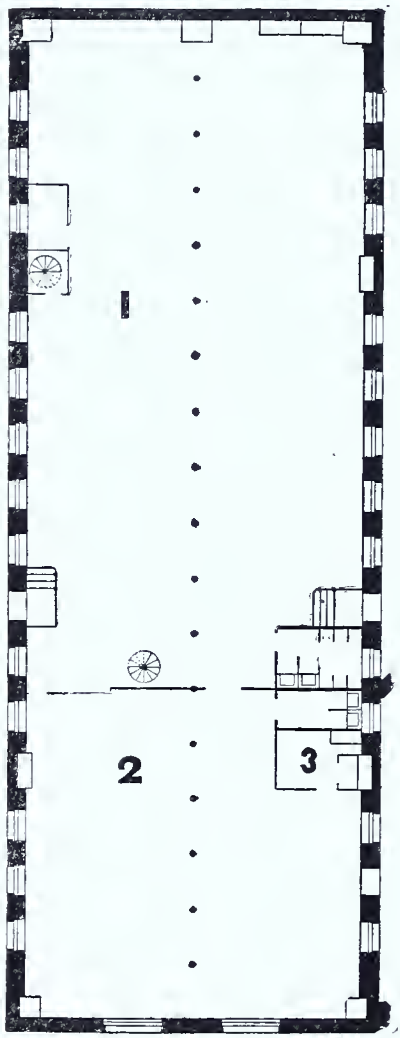
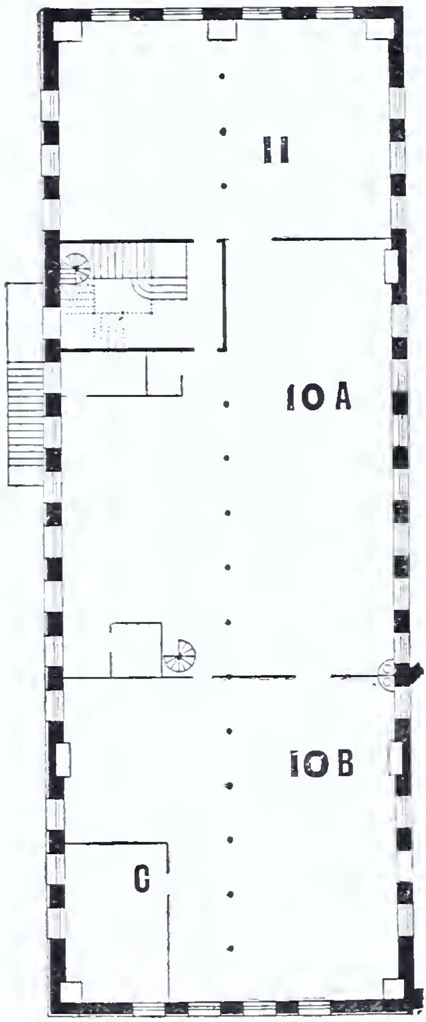


1, Steam and Hydraulic Laboratory. 2, Laboratory of Applied Mechanics.

ENGINEERING BUILDING;

FIRST FLOOR.



10 A, Hydraulic Laboratory. 10 B, Laboratory of Applied Mechanics.